Solarelastic Stability of Solar Sail Structures

Completed Technology Project (2012 - 2015)

Project Introduction

In order to avoid an unintended failure in proposed Solar Sail spacecraft due to solarelastic interactions it is important to develop an analytical framework for predicting the interaction between the solar pressure and the solar membrane. I will develop a fully coupled membrane, solar pressure model that can be used to predict dynamic instabilities for Solar Sails. Many of the techniques will be directly borrowed from supersonic aeroelastic analysis but the analysis will specifically focus on proposed Solar Sails. Specifically I will couple a solar pressure model proposed by MacNeal [1] with finite element structural model of the Solar Sail to determine the critical dimensions for different solar pressure strengths. Furthermore, I will conduct non-linear structural analysis for the sails to determine the post critical behavior and ensure that the stress induced by flutter will not cause catastrophic sail failure. In addition I will validate my theoretical model with experimentation. Because the solar pressure will not be measurable on the ground where aerodynamic forces will dominate, alternate methods of simulating the solarelastic response will be developed. For my research I will use piezoelectric patches to simulate the generalized forces in the most important structural modes. The most important structural modes will be determined by the unstable eigenvalues in the solarelastic analysis and the critical mode shape from the corresponding eigenfuctions. As with the theoretical analysis, initial simulations will be done on the simply supported rectangle case. [1] MacNeal, R. H., Structural Dynamcis of the Heliogyro, NASA CR-1745, 1971

Anticipated Benefits

In order to avoid an unintended failure in proposed Solar Sail spacecraft due to solarelastic interactions it is important to develop an analytical framework for predicting the interaction between the solar pressure and the solar membrane.

Project Image Solarelastic Stability of Solar Sail Structures

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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Responsible Program:

Space Technology Research Grants

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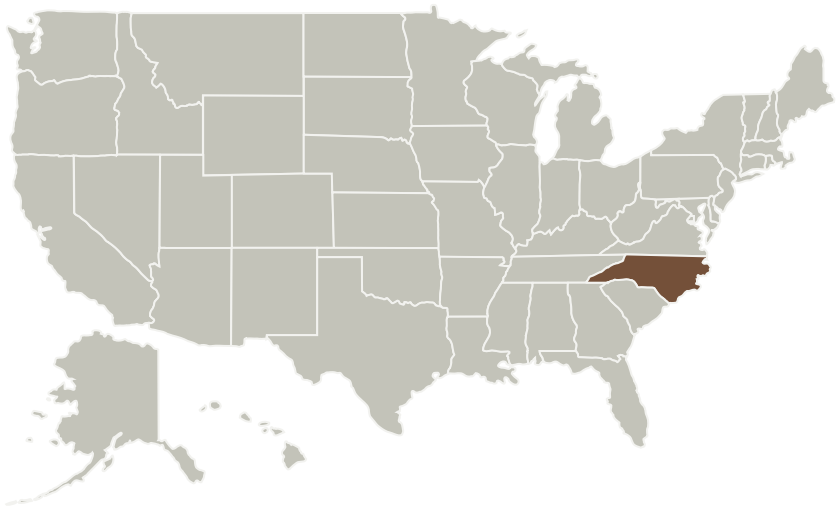
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Duke University	Supporting Organization	Academia	Durham, North Carolina

Primary U.S. Work Locations
North Carolina

Project Management

Program Director:
Claudia M Meyer

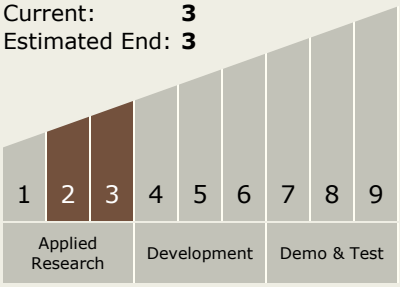
Program Manager:
Hung D Nguyen

Principal Investigator:
Earl H Dowell

Co-Investigator:
Samuel C Gibbs

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX01 Propulsion Systems
  - TX01.4 Advanced Propulsion
    - TX01.4.1 Solar Sails

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Images

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Project Image Solarelastic Stability of Solar Sail Structures
(https://techport.nasa.gov/image/1825)

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html